MFM investigations of particles with configurational anisotropy fabricated by scanning probe and microsphere lithography

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Patterned magnetic nanostructures, such as two-dimensional dot arrays, have attracted a great deal of interest due to their potential applications in many technologically important fields, such as magnetic information storage [1] or nonvolatile magnetic random access memory (MRAM) [2]. Recently the scientists have intensively studied the usage of the Villari effect (the change of magnetic properties of a solid under mechanical strain) for magnetic reversal processes of micro- and nanostructures. It is caused by the possibility to significantly reduce the energy for rewriting of a bit of magnetic information by the simultaneous usage of the magnetic field and mechanical tension and to create the magnetoelectric random access memory (MeRAM). Usually, the uniformly magnetized elliptical particles having two stable states with the opposite magnetization are used for the fabrication of memory cells (MeRAM) [3]. The particles with configurational anisotropy (for example, triangular and square ones) can have several stable states with quasiuniform («near-uniform») magnetization and in principle, they can be used for fabricating MeRAM [4].

In our work, the magnetization in triangular Py (Ni79%, Fe16%, Mo4%) particles of the micron and submicron size fabricated by scanning probe lithography [5] and microsphere lithography [6] were studied by magnetic force microscopy (MFM). Using the scanning probe lithography method, triangular submicron Py particles with different concave wall degrees (from the isosceles triangle to the particles with a shape close to the letter Y) were fabricated. In microsphere lithography Py was deposited in ultrahigh vacuum over the mask made of the two-dimensional array of close-packed 5 μm SiO_2 spheres. The triangular patterned Py particles with concave walls were fabricated on the Si substrate after removing SiO_2 spheres at the last stage.

The experimental MFM images were compared with the results of the computer simulation of its magnetic structure to detect the magnetization distribution in the particles with different sizes and shapes. These calculations were carried out by OOMMF [7]. This magnetization distribution was used for the simulation of the MFM images, which then were compared with the experimental results. The coincidence of the model image with the experimental one made it possible to conclude about the correct calculation of the magnetization distribution. The change of the magnetization distribution in the triangular submicron Py particles induced by the external magnetic field, mechanical compression or tension was also investigated.

These results may be useful for the fabrication of a new type of a straintronic cell (MeRAM) in the form of a heterostructure consisting of two planar particles with configurational anisotropy separated by a tunnel-transparent gap and placed on the piezoelectric substrate. The magnetization of the first particle was fixed and that of the second particle was relatively free.

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